# REPORT

## A PROPOSED PULVERIZED COAL INSTALLATION FOR THE REO MOTOR CAR COMPANY

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Steam engineering
Fuel

Mechanical engineering
V.

# A PROPOSED PULVERIZED COAL INSTALLATION

For

THE REO MOTOR CAR COMPANY

A REPORT SUBMITTED TO THE FACULTY

OF THE

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By

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Candidates for the degree of

Bachelor of Science

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# Part 1

## Introduction.

This problem was chosen upon the recommendation of Mr. W.G. Hildorf, of the Reo Motor Car Co., It is inevitable that within a few years fuel oil will, due to the decreasing supply, increase in price until the cost will prohibit its use in heat treat work.

Pulverized coal is being used to some extent at the present time in heat treat work, and is used quite extensively in power plants.

In this report we will endeavor to show the feasibility of the application of a pulverized coal installation to the heat treat and power plant departments, the cost of installation, the equipment needed, and the difference in costs of operation of the two systems.

We wish at this time to express our indebtedness to Mr. W. G. Hildorf for his assistance in making available to us the data and information that we obtained from the Reo Motor Car Company.

## Part 11

### Discussion of the Use of Powdered Coal in Metallurgical Furnaces and Under Boilers.

Although powdered coal has not been used as a fuel for metallurgical furnaces or boilers for perhaps more than fifteen years, it has been used successfully in the cement industry for more than twice that long. As fuel oil has risen in price powdered coal systems have been installed to take the place of the oil systems, and as coal has become harder to obtain, stokers have been taken out and powdered coal burners put in their place.

Of course, something more is necessary, for the efficient burning of powdered fuel, than the mere removing of an oil burner and putting in its place a powdered coal inlet, or removing a stoker and cutting a hole in the side of the boiler setting for the admittance of a powdered coal burner. In many cases, in order to change from gas, coal or oil to powdered coal, it is necessary to completely redesign the combustion chamber of the furnace or boiler setting.

A few words on the design of furnaces for pulverised fuel may be of interest. The primary requisite for good results is to maintain low velocities in the furnace. The combustion is no less complete with high velocities, but this will result in damage to the linings and in their erosion.

A furnace cubical in shape usually gives the most satisfactory results.

The burners should inject the coal under low pressure and should permit of varying the density of the mixture in the burner itself. Their location and number will depend on the size of the boiler and rating required, and also may be varied to suit the grade of fuel. High boiler ratings such as are used in modern boiler practice can be obtained when desired, and such over ratings should be predetermined and the furnace volume designed accordingly. (Note. The last two paragraphs have been quoted from a paper by F.A. Scheffler and H.G. Barnhurst, "Pulverized Coal for Stationary Boilers" presented at Spring Meeting of A.S.M.E. Detroit, Michigan June 16 to 19, 1919.

While it is not absolutely necessary to redesign the combustion chamber in order to make the fire burn, if high efficiencies are desired, and high efficiencies are necessary if powdered coal equipment is to replace stokers and oil systems, the furnace design must conform to the design most efficient for burning powdered coal.

Probably the main incentive for developing powdered coal equipment has been the hopes that an inferior grade of coal may be used in this way than a stoker installation is capable of handling. C. F. Herington author of "Powdered Coal as a Fuel" states: "Most of the experience hitherto obtained has been on high grade, highly volatile, soft coals, and efforts to burn inferior grades have often led to disappointment. It is in recent practice, and in the hands of only a few investigators, that good results have been obtained from inferior soft coals and from anthracite. All of the most recent developments for steam generation have been made with anthracite culm, at one time definitely abandoned as a suitable fuel for powdering. Powdered coal, like ordinary commercial coal, should be practically free from sulphur, for all but the most exceptional applications.

F. A. Scheffler and H.G. Barnhurst in their paper state that there are three main advantages of the pulverized fuel equipment over stoker equipment. These advantages are: reliability, cost and adaptability.

First, in comparing the stoker to the pulverized fuel equipment, we find that the factor, reliability, depends on two items: apparatus for preparing and presenting the fuel for combustion, and continuity of operation of the furnace itself. On a stoker installation the first of these includes the stoker itself. Neglecting the inherent defects in any system that presents a metal mechanism to the action of high temperatures, it may be admitted radily that the stoker system is satisfactorily reliable, with respect to its apparatus for preparing and presenting the coal for combustion.

The corresponding mechanisms for pulverized coal are equally reliable. This fact is proved by their widespread use for years in the cement industry. Proper design by engineers of standing who are specialists in this line has made negligible the danger of dust explosions, the occasional occurances of which in years past have furnished ammunition to the opponents of pulverized fuel.

The second condition for reliability is the continuity of operation of the furnace. During operation, it has been found that the pulverized fuel installations and stokers are on a par as far as this item is concerned. However the advantage seems to lie with the pulverized fuel, for several reasons. The mechanism is altogether outside of the furnace hence cleaning and adjustment and the making of the few repairs required need not interupt the operation of the furnace. In case of necessity the fire may be ignited and quickly brought to full intensity, or it may be extinguished almost instantly. Greater uniformity of flame and temperature is conducive to longer life of the furnace lining in a properly designed furnaces, and to the minimum variation in furnace efficiency.

The second factor refers to the cost per B.T.U. delivered to the boiler. The various items entering into the cost by the stoker system comprise power, repairs and maintainance, labor, interest on investment, depreciation, insurance and taxes.

With pulverized fuel equipment, the cost of fuel for the drier should be added to the preceeding items. It is clear that it would be cheaper to remove the excess moisture from the coal before it enters the fire, as in the case of the stoker, because in this case the evaporation damps the fire, increases the content of the inert gases and at the same time carries off a very perceptable amount of heat.

The final factor of the cost, furnace effeciency, which governs all of the others, results in all respects to the advantage of pulverized fuel for the following reasons:

First the pulverized fuel enters the combustion chamber in a finely divided state, being introduced with air at low pressure, and is approximately perfectly mixed with air for theoretically perfect combustion. Therefore no excess air is required for burning. With the stoker it is impossible to burn the fuel without excess fuel due to the fact that it is impossible to get a uniform bed of fuel on the grate or stoker. Furthermore if it is necessary to introduce excess air with pulverized fuel it can be done in exact amounts. In other words the combustion and character of the fire is at all times under the control of the operator.

Second, in pulverized form all of the combustible is burned a condition certainly impossible with lump-coal firing either by hand or stoker. It is not unusual to find 20 or 30 percent of carbon in ash refuse from grate or stoker fired boilers.

Third, with pulverized fuel there are no standb losses with change of load or when shutting down, such as banked fires.

Third with properly designed pulverized fuel appratus nothing of a mechanical nature takes place in the furnace. In stoker and grate firing not only is the mixing of the air done in the furnace, but the presentation of fresh surfaces of the combustible to the air supply must take place by the removal of the ash.

In considering the third factor, adaptability, it can be shown that pulverized coal is again preeminent. The primary feature is the possibility of burning all grades of fuel with out effecting the efficiency of the furnace. To burn powdered anthracite and very low grades of fuel requires a furnace allowing a return flow of flame past the incoming flame, to heat up the incoming fuel, and in a furnace of this type, fuel containing over 50 per cent ash has been burned with high effeciency. The stoker is very much restricted in this respect.

The flexibility in the use of pulverized fuel is perfect, and the fire may be instantly adjusted to suit any condition, any condition of overload or lower load, including the cutting in and out of boilers. The paramount importance of this feature and the utter imposibility of approaching it with stoker or grate firing is readily evident. Futhermore, the operation and the determination of conditions for complete combustion may be made automatic, the result being a smokeless and sootless boiler plant, which is essential in modern cities.

Thus it can be seen that, taken as a whole, pulverized fuel equipment is superior in every way to stokers. It is admitted, however, that pulverized fuel is not applicable to every plant. John Anderson, Chief Engineer of Power Plants, Milwaukee Electric Light and Railway says "A plant of less than 2500 developed boiler horsepower on a twenty-four operating basis should not consider using powdered fuel. The amount of coal pulverized per day, the cost of installation, and the labor for operating the preparation plant, when studied show that the installation would not be practicable". Refering to the cost again, we see that the items which go to make up the cost of pulverizing are: power, repairs and maintainance, coal for drying, labor, interests on the investment, depreciation, insurance and taxes. In a given locality, the cost of all these items will increase with the size of the plant, except the labor. F. A. Schaffeler and H. G. Barnhurst say in their paper on pulverized coal for boilers " The item of labor is the greatest variable in connection with the pulverizing of coal, due to the increased output that can be obtained in larger plants per man employed. For example, assuming that labor costs forty cents per hour, a plant that has a daily capacity of 100 tons, is properly designed and equipped, will require approximately 34 labor hours to prepare the fuel and deliver it to the conveyors, whereas in a plant having a daily capacity of 1000 tons, 115 labor hours are required. Therefor the labor cost would be 14 cents per ton in a 100 ton plant, only 4 cents per net ton in 1000 ton plant and as low as 2 1/2 cents per net ton in a plant of 5000 tons daily capacity".

Very little information is available on the use of powdered coal in heat treating furnaces, that is relating to the conditions effecting the efficient burning. It is known, however, that powdered coal is used successfully in all kinds of furnaces and that it is replacing oil, gas and other fuels. It stands to reason that the same factors would effect the burning of the pulverized fuel in these furnaces as under boilers the only difference being that it would be on a smaller scale in the heat treating furnaces. Probably the main reason why pulverized coal is replacing oil is due to the increased cost of the fuel oil, thus making the cost per B.T.U. more with oil than with pulverized coal. There is also the argument by some engineers that the heat with powdered coal is superior to heat with oil, for heat treating work .

Thus in general it can be seen that powdered fuel is superior to other fuels, for ordinary work, and it is the general belief among engineers famaliar with fuels and fuel burning apparatus, that in the near future, powdered coal will be preeminent in the industrial world as a fuel.

## Part 111.

### Data.

In order to obtain as nearly correct a solution of this problem as possible, we wrote to several companies engaged in the manufacture and installation of pulverized coal equipment, asking them for copies of bulletins advertising their equipment. We stated the problem to them and asked that they furnish us with estimates as to the feasibility of the proposition, the probable cost, equipment needed, and what saving, if any, would be derived from the use of pulverized coal.

We corresponded with the following companies in regard to this proposition:-

Quigley Furnace Specialities Company.
28 Cortlandt St.,
New York.

Combustion Economy Corporation.
1901 S. Rockwell St.,
Chicago, Ill.

Fuller Engineering Company,
Allentown, Pa.

The Bonnet Company.
Canton, Ohio.

Fuller - Lehigh Company
Fullerton, Pa.

American Industrial Engineering Co.,
Monadnock Building,
Chicago, Ill.

Combustion Engineering Company,
11 Broadway.
New York.

These companies offered to assist us if we would furnish them with the necessary information and data concerning the Reo heat treat department and boiler room. We complie this data from the records of the company, personal observation, and information furnished us by the officials of the Reo Motor Car Company.

Prints were obtained of the boiler settings, coal handling equipment, and layouts of the heat treat departments, and boiler room.

Sets of the data and prints were sent to each of the aforanamed companies. The data furnished the companies is given on the following pages.

BOILER ROOM DATA SHEET

No. of boilers - 7

No. in batteries - 6

Type and make - 6 McNaull; 1 Springfield.

Rated horsepower - 4-400; 2-550; 1-870

Arrangement of baffles - Vertical.

Dimensions of furnaces - Given on blue prints.

Kind of stokers - Jones Std. and Jones A.C. on Springfield.

Kind of draft - Forced.

Size and height of stack - 12 ft. X 175 ft.

Vacuum at breeching in inches of water -.75

Coal handling equipment - Bucket elevator, flight conveyor over bunker.

Hours operated per day - 24.

Days per year - 300

Overload carried Practically none.

Number of men to operate and cost:-
Day shift - 2 men - 12 hours - 60 cents per hour.
Night shift - Same as day shift.

No steam used for generating electricity.

FUEL DATA.

Kind - West Va. Cost per ton - $2.35

Grade - Mine run. Freight per ton - $4.75

Amount used per day (24 hours) - 80 tons aver.

Annual consumption - 24000 tons.

ANALYSIS.

Volatile - 36.4% B.T.U. - 12000 - 14000

Ash - 4.97% Fixed carbon - 57.4%

Sulphur - 1.16% Moisture - Not determined

The following blue prints ~~will~~ were be sent under separate cover: -

Plan showing tracks and buildings in vicinity of boiler room; coal handling equipment; boiler settings of 400 H.P. McNaull and 870 H.P. Springfield.

FURNACE DATA.

Cyanide Pots.

Furnaces #1 - 21 - 22 - 23 - 24 - 25

Make - Strong, Carlisle and Hammond, Rebuilt.

Temperature - 1400 deg. F.

Time per heat - 14.17 minutes.

Weight of metal per heat per furnace - 40#

Furnaces.

Furnace #2.

Make - S.C. and H. #17 Rebuilt.

Temp. - 1550 deg. F.

Time - 55.01 min.

Wt. of met-al per heat - 137.5#

Furnace #3 - 4.

Make - Bellevue #7.

Temp. - 1425 deg. F.

Time - 60 min.

Wt. of metal per heat - 200#

Furnace #5 - 6.

Make - S,C and H. #4.

Temp. - 1425 deg. F.

Time - 64.4 min.

Wt. of metal per heat - 331#.

Furnace #7 - 7.

Make - S,C and H. #8.

Temp. - 1500 deg. F.

FURNACE DATA.

Time - 52.24 min.

Wt. of metal per heat - 320#.

Furnace #13.

Make S,C and H. #2485.

Temp. - 1525 deg. F.

Time - 50 min.

Wt. of metal per heat - 625#

Lead Pots.

Furnaces #14 to #20 incl.

Make - S, C and H. Rebuilt.

Temp. - 1550 deg. F.

Time - 36.06 min.

Wt. of metal per heat - 142#.

Next hhree furnaces in the line of the lead pots (as shown on blue print) are preheat furnaces and are only used intermittenly.

Carburizing.

Furnace #41.

Make - S,C and H. Rebuilt.

Temp. - 1725 deg. F.

Time - 11 hours.

Wt. of metal per heat incl. wt. of box - 1315#.

# FURNACE DATA.

## Carborizing Furnaces.

Furnaces #42 to 58 incl. and #61-62-6[illegible]-64.

Make- Packard Type Furnace. This refers to all numbers above 60.

Make #41 - 50 incl. - S,C and H. Rebuilt.

Temp. - 1725 deg. F.

Time - 11 hours.

Wt. of metal per heat - 1460#

Furnaces #59 - 60 - 63 - 63.

Make - Packard Type Furnace.

Temp. - 1725 deg. F.

Time - 11 hours.

Wt. of metal per heat - 2625#

Furnace #70.

Make - American Gas Furnace Co.,

Temp. - 1425 deg F.

Time - 75 min.

Wt. of metal per heat - 153#

## Forging Furnaces.

Type A.

No. of furnace of this type - 3

Temp. - 2000 deg. F.

Wt. of material heated per day per furnace - 8500 #

Make - Built by the Reo Motor Car Co.,

FURNACE DATA.

Type B.

No. of furnaces of this type - 3

Temp. - 2000 deg. F.

Wt. of metal heated per day per furnace - 6330#

Make - Built by the Reo Motor Car Co.,

Type C.

No. of furnaces of this type - 3

Temp. - 2000 deg. F.

Wt. metal heated per day per furnace - 380#

Make - Built by the Reo Motor Car Co.,

Type D.

No. of furnaces of this type - 5

Temp. - 2000 deg. F.

Wt. of metal heated per day per furnace - 2120#

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Since no prints of the cross sections of the furnaces were available, the Manufacturers name and number of furnace has been given in all cases where it could be found. In the cases where this information is given, the dimensions of the furnaces may be obtained from the Manufacturer's catalogue. The inside dimensions of the following furnaces will be given as the Manufacturers name and number could not be ascertained:

## FURNACE DATA.

Furnace #41 - Hearth 3' X 5 3/4' , 2 1/2' high.

Furnace #42 - 46 incl. - Hearth 3 1/4" X 7 1/4'. 1 3/4' high.

Furnace #47 -50 incl. - Hearth 3 1/4' X 8 1/4' 1 3/4' high.

Furnace #51 - 58 incl. - Hearth 3' X 7'. 2' high.

Furnaces #61 - 62 - 64 - 64. Same as #51 - 58.

Furnaces #59 - 60 - 63 - 63. - Hearth 3 1/4 ' X 12'. 3 1/4' hig,

The lead pots and cyanide pots are of the strong, carlisle and Hammond make, rebuilt. A print was sent of the cyanide furnaces. The lead pot furnaces are the same except that they are 6 inches higher than the cyanide furnaces.

The data given on the preceeding sheets has been collected as carefully as possible. In all cases where possible it is based on the records of the Reo Motor Car Company. There was no recorded data on the forging furnaces. Consequently the data given on these furnaces is more or less of an approximation.

In the foregoing sheets of data, where the item "Wt. of metal per heat", is given, it refers to the Wt. of metal per heat per furnace.

## FUEL OIL DATA.

Kind - fuel oil

Gravity - 28 - 30 Baume at 60 °F

FURNACE DATA.

Amount used per day of 24 hours - 3900 gal.

Amount used per year - 1,170,000 gal.

Cost per gal. - 4 1/2cents.

Air Blast Data.

The air used by the oil furnaces is supplied by a Western Electric Centrifugal Air Compressor. The compressor is of single stage type and is driven by a 50 h.p. motor, direct connected. This set is duplicated by two 25 h.p. sets.

The air is supplied at a pressure of 24 oz.

The data concerning the capacity of the compressor using an efficiency of 50% . The result obtained was 3820 cu. ft. per min. for the 50 h.p. set.

Note: - The Springfield boiler mentioned in the boiler data sheet is now being installed, so none of the data in regard to fuel consumption, etc., refers to this boiler.

## Part IV.

### Analysis of Estimates.

In the following pages we will give the substance of the reports furnished us by the several companies we corresponded with in regard to this problem.

The first proposal considered will be the one furnished by the Quigley Furnace Specialties Co., The proposal is the most carefully prepared and is given in the greatest detail of any of the several we have received. The substance of this report will be given in detail.

Analysis of the other reports will be given using this one as a basis of comparison.

Quigley Furnace Specialties Company.

We propose to furnish to the Reo Motors Company the following equipment for preparing, distributing and burning powdered coal at their plant.

The powdered coal burning equipment is for use in connection with

7 - Boilers.

70- Small Heating Furnaces.

10 - TON MILLING PLANT

1. Special track hopper constructed of heavy steel plate with reinforcing and stiffening angles which will have an opening at the top for receiving the coal 12 ft. by 12 ft.

The necessary track girders will be supplied as well as steel grissley bars with 8" x 8" openings placed below the track girders.

A suitable opening will be provided in the bottom of the track hopper for connection to the reciprocating feeder which regulates the flow of coal to the crusher.

1. Sheet steel connection box provided with connecting angles for attaching the reciprocating feeder to the track hopper.

1. Reciprocating feeder for regulating the flow of coal to the crusher, which will be constructed of steel

plate properly reinforced where necessary and provided with driving mechanism, etc., for operating same.

1. Steel plate chute connection between reciprocating feeder and crusher.

1. Single roll 24" x 24" coal crusher will be supplied for reducing the size of the coal to 1 1/4". The crusher will be of heavy substantial design with reduction gearing, fly wheel and safety devices, such as spring releases, shear pin, etc., to safeguard the machine in case of the introduction of some hard foreign substance. The roll shaft will be extended on one end to which will be attached the necessary sprocket for driving the reciprocating feeder.

1. Sheet steel cover suitable reinforced will be provided for covering the pit between the track hopper and the crushed coal elevator.

1. Sheet plate chute for directing the coal from the discharge of the crusher to the boot of the crushed coal elevator.

1. Chain and bucket elevator having a capacity of 50 tons per hour for elevating the crushed coal to the belt conveyor with magnetic separator pulley which in turn discharges to the crushed coal bin.

This elevator will be constructed of sheet steel with connecting and stiffening angles and will be made dust-tight.

The necessary reduction gearing at the elevator head will be provided also the take up in the boot and power will be

transmitted from the motor to the idler shaft at the head of the elevator by means of gearing.

1. Small structural steel platform with hand rail will be supplied for attachment at the head of the crushed coal elevator.

This platform will give access to the elevator head and will also serve as a base for the motor which operates the elevator.

1. - 24" belt conveyor with magnetic separator pulley at delivery end to conduct the coal from the crushed coal elevator to the crushed coal bin. The conveyor will be totally enclosed in a sheet steel housing provided with inspection doors. Idler pulley and take up will be furnished. Framing for walkway will be attached to the structural work of the conveyor housing.

1. Magnetic separator pulley 12" dia. by 20" face operating with direct current will be provided. This pulley is to separate tramp iron from the coal. A reject spout of iron from the separator to the floor will be provided, together with steel plate chute from the pulley to the crushed coal bin. The necessary chain drive with sprockets for operating the belt conveyor will be provided.

1. Screw conveyor for delivering the crushed coal into the storage bin.

1. Crushed coal bin, having a capacity of 100 tons. Bin will be constructed of substantial steel plate with suitable

stiffening members and rigid structural steel support will be supplied for sustaining the crushed coal bin above the firebox of the dryer.

Sheet steel cover will be provided for to tally enclosing bin.

Rack and pinion operated gate will be supplied and attached to the bottom of bin and the necessary mechanism and hand chain for operating this gate from the floor will be supplied.

Hand railing will be provided on the side of the crushed coal bin.

3. Stock tester gauges will be supplied for determining the amount of coal in bins.

1. Screw feeder will be supplied to regulate the flow of coal from crushed coal bin to the dryer. Necessary sheet steel chute from the feeder to the dryer inlet will be furnished. Sprocket and chain and ratchet drive for operation of the feeder will be included.

1. Double shell dryer which will reduce the surface moisture of the coal from 10% to about 1% at the rate of 10 tons per hour. Dryer is of the semi-indirect type with central flue, substantial girth gear and reduction gearing for rotating the shell. The two riding rings attached to the shell will be supported on self-aligning rolls. Shell will be 70" dia. 35' long.

The necessary firebox castings, buckstays and grates will be supplied. Shell will be belt driven from the countershaft.

1. Countershaft, complete, with pulleys and hangers for transmitting power from the motor to the dryer and screw feeder. Screw feeder and countershaft supports will be furnished for attachment to the framing of crushed coal bin.

1. Auxiliary stack, which will be attached to the firebox for short-circuiting the products of combustion from the firebox when shutting down the dryer.

1. Cyclone separator with chute and exit stack and structural steel support will be supplied. The products of combustion from the firebox of the dryer will pass through the dryer shell and thence to the fan, cyclone collector and to the atmosphere.

1. Structural steel platform for supporting the exhauster furnished with the dryer as well as the motor for operating it and the dryer.

1. Housing for the discharge castings on the dryer will be included which will form chute to the boot of the dried coal elevator.

1. Recording thermometer with couple and recording dial to register the temperature at the outlet of the dryer.

1. Dried coal elevator, having a capacity of 35 tons per hour will be furnished. Dried coal elevator will be of

the same general type as the crushed coal elevator. Steel chute will be supplied for discharging the dried coal to the dried coal conveyor.

Suitable steel framing will be supplied upon which motor which drives the elevator will be mounted.

1. Small steel platform will be supplied to give access to the heads of elevator bearings,etc.

2. Sheet steel dried coal bins will be supplied having a capacity of 3 tons each. Bins will be properly reinforced with stiffening members. A rigid structural steel frame work will be supplied for supporting the dried coal bins. Dust-tight manhole frame of special design will be attached to the steel plate cover of each bin for giving access to inside of bins. At the bottom of each bin a rack and pinion slide gate will be supplied for shutting off the coal to pulverizers. Stock tester gauges for determining the amount of coal in bins will be supplied.

2. Sheet steel chutes will be furnished for directing the coal from the dried coal bins to pulverizers.

2. 5 roller lowside mills including exhausters for the air separation of the coal and the necessary galvanised iron piping from the mills to the exhausters and from the exhausters to the cyclone separators and from the cyclone separators back to the mills. The primary cyclone collectors of which there will be two will be supplied, together with two secondary collectors.

2. Structural steel platforms for supporting the exhausters furnished with the mills.

2. Structural steel supports for cyclone collectors furnished with the mills.

2. Structural steel platforms will be supplied for supporting the motors which drive the pulverizers and exhausters.

2. Sets of sheet steel chutes will be furnished for conducting the coal from the powdered coal bins to the blowing tank unit.

1. 5 TON BLOWING TANK UNIT:

1 Sheet steel powdered coal bin, having a capacity of 5 tons will be furnished and will be properly reinforced with stiffening angles where required.

1. Sheet steel cover will be attached to the bin and a manhole frame and cover of special dust-tight design will be attached to the top plate cover of bin for giving access to the bin.

1. Stock tester gauge will be furnished for determining the amount of coal in the bin. To the bottom of the bin will be attached dust-tight gate of special construction for shutting off the coal from the blow tank.

1. Flexible connection between the powdered coal bin and blowing tank will be included.

1. Substantial rigid structural steel framework for supporting the powdered coal bin will be furnished.

1. Patented powdered coal transport blowing tank will be supplied 6' dia. and 18' high. Tank will be capable of receiving 5 tons of powdered coal at one charge, and the shell will be built of substantial steel plate properly caulked and rivitted. Quick-opening inlet valve will be attached to the top head of blowing tank with necessary mechanism for manipulating the valve from the floor.

Pressure gauge, safety valve, air inlet control valve and air pressure reducing valve will be supplied.

Blowing tank will be built for a working pressure of 100# per sq. inch.

2. 4" patented flanged hand-operated coal switching valves for distributing the powdered coal from transport line to bin. Lever and hand chain for operating these valves will be furnished.

1. Indicating platform scale with steel platform, large indicating dial and tare beam will be furnished with this unit. Dial will be divided so as to read in 100# divisions and will record up to 10,000#. By this means all the powdered coal is accurately weighed and charged against each powdered coal bin at the furnaces.

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9 Steel ladders to give access to the various platforms and elevator heads will be furnished.

1. Signal systemconsisting of a panel with push buttons, lights and annunciator for the milling plant and small panels with light and push button on each bin station.

All necessary bolting for operating the above specified machinery will be furnished.

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## DISTRIBUTING AND BURNING EQUIPMENT

## for

## 7- Boilers

4. Sheet steel hoppers, 2 having a capacity of 15 tons each and 2 having a capacity of 20 tons each with 18 discharge openings. A manhole frame of special design will be attached to the steel cover of each hopper. Hoppers will be provided with steel covers and will be made dust-tight. 18 extension castings will be furnished.

18. Dust-tight gates of special construction will be supplied.

4. Stock tester gauges will be supplied for determining the amount of coal in bins at any time.

8. Vent pipes for attachment to top plates of hoppers.

4. 4'2" dia. cyclone collectors of special construction will be supplied for use in connection with the compressed air transport system, together with exit stacks and distributing chutes.

4. Structural steel supports for cyclone collectors.

18. Powdered coal feed controllers, each having a maximum capacity of 1250# powdered coal per hour. These feeders

are substantially designed and are provided with two shutters operated from the outside by means of wheel or hand chain wheel, so that the amount of coal fed by each can be readily regulated by the furnace heater as would be the case with oil or gas.

4. Controller drive countershafts with bearings, etc., will be supplied.

18. Controller drive sprockets and chains will be furnished.

18. Sets of coal and air pipes to burners.

18. Powdered coal burners of special design will be furnished.

18. Powdered coal burner supports.

2 - Primary air blowers, 1 having a capacity of 5000 Cu. ft. and one having a capacity of 2000 cu. ft. per min. at 6 oz. pressure each.

2. Secondary air blowers, 1 having a capacity of 10000 cu. ft. and one having a capacity of 27500 cu. ft. per min. at 1 1/4 oz. pressure each.

Primary and secondary air blast lines.

2. 4" patented flanged hand-operated coal switching valves for distributing the powdered coal from the transport line to bins. Levers and hand chains for operating these valves will be furnished.

18. Gird type blast gates will be furnished.

4. Ladders to give access to top of bins.

8. Sets of bolts and washers.

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## DISTRIBUTING AND BURNING EQUIPMENT

for

70- SMALL HEATING FURNACES.

7. Steel hoppers, 4 having a capacity of 3 tons each and 3 having a capacity of 4 tons each. A manhole frame of special design will be attached to the steel cover of each hopper. Hoppers will be provided with steel covers and will be made dust-tight.

7. Stock tester guages will be supplied for determining the amount of coal in bins at any time.

7. Vent pipes for attachment to top plates of hoppers.

7. 4'2" dia. cyclone collectors of special construction will be supplied for use in connection with the compressed air transport system, together with exit stacks and distributing chutes.

7. Structural steel supports for cyclone collectors.

5. 4" patented flanged hand-operated coal switching valves for distributing the powdered coal from the transport line to bins. Levers and hand chains for operating these valves will be furnished.

100. Syphon type feeders will be furnished.

100. Sets of coal and air pipes to burners.

2. Secondary air blowers, 1 having a capacity of 2000 cu. ft. and 1 having a capacity of 7500 cu.ft. per min. at 1 1/4 oz. pressure each.

1. Primary air blast line.

2. Secondary air blast lines.

100. Grid type blast gates will be furnished.

7. Ladders to give access to top of bins.

Anchor bolts and washers will be furnished.

................oOo................

## ADDITIONAL EQUIPMENT NOT COVERED BY THIS PROPOSAL BUT NECESSARY TO COMPLETE PLANT to be furnished by REO MOTORS COMPANY

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1. | - 30 | H.P. | Motor, | 220 V. | 3 ph. | 60 cy. | to drive | Crusher, |
| 1. | - 10 | " " | " | " " | " " | " " | " " | Crushed coal elevator |
| 1. | - 80 | " " | " | " " | " " | " " | " " | Dryer, |
| 1. | - 10 | " " | " | " " | " " | " " | " " | Dried coal elevator |
| 2. | -100 | " " | " | " " | " " | " " | " " | Pulverizers, |
| 4. | 5 | " " | " | " " | " " | " " | " " | Controllers. |
| 1. | 5 | " " | " | " " | " " | " " | " " | Primary Air Blower, |
| 1. | 15 | " " | " | " " | " " | " " | " " | " " " |
| 1. | 3 | " " | " | " " | " " | " " | " " | Secondary Air " |
| 2. | 5 | " " | " | " " | " " | " " | " " | " " " |
| 1. | 20 | " " | " | " " | " " | " " | " " | " " " |

Dryer firebox setting.

Crusher & Motor supports.

Wiring.

Compressed air piping.

Excavation and foundation.

Erection.

Building.

650 ft. transport line, scavenging pipe, fittings, etc.

ESTIMATED COST OF THE ABOVE.....$39,008.00

Equipment furnished by Quigley Furnace.
Specialties Co., in accordance with
the foregoing quotation ..............$160,000.00

ESTIMATED TOTAL COST ...... 199,008.00

................oOo. ............

QUIGLEY FURNACE SPECIALTIES COMPANY.

The materials, which we are to furnish, in connection with this proposal cover the entire mechanical equipment from the track hopper to the burners with the exception of the air compressor and air receivers, which we understand are already installed.

On the last page of the proposal, you will note a list is made of various items, which the Reo Motors Company would have to furnish in connection with this layout. These items include all which are normally encountered with the exception of furnace changes.

On some of the small heating furnaces the powdered coal will probably be fired on one side of the hearth and the secondary air would be admitted directly opposite, thus preventing the flame from impinging on the brick work.

On some of the larger heating furnaces it would probably be necessary to build a small combustion chamber, sufficient in size so that the coal would be entirely consumed before reaching the hearth.

You have not mentioned in your data whether or not these furnaces were equipped with stacks or exhaust systems.

It is assumed that some of the larger furnaces have stacks. If not they will probably be necessary.

The small furnaces would give better operation with less dust in the workroom if a small exhaust system was installed to carry off the products of combustion. This would also carry away a large percentage of the ash and therefore requires less labor to clean the furnaces.

You will probably be interested concerning the cost of pulverization and the power required for preparing, distributing and burning the coal.

Concerning the cost, we find from our records that with present day prices of labor and supplies and allowing 1 cent per K.W. hour for energy that the cost per ton prepared, distributed and burned in a 10 ton per hour plant, would be from $1.25 to 1.65 varying according to local conditions.

The plant, which we have recommended, would be operated about 20 hours per day, probably two shifts with 10 hours each. It is sufficient to prepare, distribute and burn 10 tons of Indiana or Illinois betuminous coal per hour, provided the moisture in the coal received does not run over 10%.

Concerning the power required, we believe that 20 K.W. hours per ton of coal in a 10 ton per hour plant, would be sufficient. This includes all power from the time the coal is received until it is burned.

All our equipment, such as chutes, elevators, conveyors and air transport systems are dust-tight in operation, having been designed especially for this purpose and we have many milling plants which are models of cleanliness.

Our air transport system consists of blow tank into which the pulverized coal is fed from the mills. When a certain amount is deposited in the tank, the inlet is closed and air pressure applied on top of the coal. This pressure varies from 20 to 65# for lines 200 to 2800 ft. long and forces the coal through a 4" standard pipe to cyclone collectors located over the various bins.

The coal requires about .8 cu. ft. of air per pound of coal transported. It will therefore be seen that coal is in a solid mass and there is absolutely no danger of fire or explosion.

Any one of the blow tanks is capable of delivering 2 to 2 1/2 full charges per hour. i.e. a 5 ton tank, such as we have stipulated for your plant, would be fully capable of delivering 10 tons of coal per hour to the furnaces.

This capability of the blow tank is not limited by the time it takes to discharge the tank but by the time it takes to charge the tank from the pulverizing mills. Five tons of coal can be discharged from the tank in at least five minutes, the coal flowing at the rate of over a ton per minute and at a velocity exceeding one mile a minute.

Concerning the feeders and burners, you will note that we have specified our standard screw feeders for use in the boiler room. These feeders are run by a constant speed motor and the amount fed is controlled by means of shutters, which are opened or closed around the shaft of an interrupted screw. The opening or closing of these shutters is accomplished by means of a hand wheel or hand chain wheel on the outside of the controller. By this means of regulation coal can be varied from zero to the full capacity of the feeder, which with the type recommended is 1225# per hour without changing the speed of the motor or using a variable speed mechanism. This means that A.C. motors can be used throughout the plant.

For the heating furnaces we have specified our syphon feeder which operates by means of compressed air at pressure of 20 to 70# per sq. inch and extracts the coal from the bins and feeds it through a small diameter pipe to the burner. This syphon feeder has been in successful operation in plants in this country for several years and is capable of wide adjustments, thus making it possible to control the temperature of the furnace as easily as with oil or gas.

On the following pages is given in detail the report and estimates from the Bonnet Co., This company, as will be noted in their report, does not consider the proposition feasible because of the low cost of fuel oil and the price paid for coal. We offer this criticism of their report: In their computations of the saving by use of pulverized coal they take the cost of pulverizing as 75 cents per ton. This does not include the cost of labor. Further, they figure cost of power used in pulverizing as $1\frac{3}{4}$ cents per K.W. instead of 2 1/2 cents per K.W. as is paid by the Reo Company. Ordinarily the cost of pulverizing ranges from $1.25 to $1.65 per ton. This increased cost in pulverizing would practically eliminate all savings in the use of pulverized coal in the heat treat department. We believe the estimate of saving in the boiler room is fairly accurate.

The following is the substance of the report of from the Bonnet Company:-

The present boiler H.P. is 2700 H.P., using 80 tons of coal per 24 hours, which gives us approximately an average of 2 1/2# of coal per hour per H.P. The new 870 H.P. Springfield boiler that is now being installed increases the boiler H.P. to a total of 3570 H.P. This gives us 3750 H.P. " 2 1/2# per hour, or 107 tons per day of 24 hours.

If the boilers are changed from stoker fires to pulverized coal, we can reasonably count on a saving of 15% or 16 tons of coal per day.

| | |
|---|---|
| 107 tons of coal at 7.10 delivered | 759.70 |
| 91 " " " " 7.10 " plus 75¢ for pulv. | 714.35 |
| Savings per day @ - - - - - - - - - - - - - - | 45.35 |

$45.35 per day x 300 days - $13605.00 saved per year.

There is a possibility that it would not be advisable to change some of the small furnaces in the heat treating department from oil to pulverized coal on account of the small amount of oil used and the expense necessary to fit up the furnaces with hoods and stacks to carry off the gases.

For sake of argument lets assume that all furnaces in the heat treating and forge department can be arranged to use pulverized coal. At present 3900 gallons of fuel oil is being used in these two departments per day. It takes one ton of coal to replace 200 gallons of fuel oil which means that approximately 20 tons of coal will be required per day to replace the 3900 gallons of oil now used.

| | |
|---|---|
| 3900 Gallons of oil at 4 1/2¢ - - - - | $175.50 |
| 20 Tons of coal at $7.1 75¢ for pulverizing | 157.00 |
| Savings per day - | 18.50 |

18.50 per day x 300 days equals $5550.00 savings per year.

| | |
|---|---|
| Savings on boilers per year | $13605 |
| Saving on forge and heat treating furnaces | 5550 |
| Total - - - - | $19155 |

The power required to convey the coal from the track hopper to the pulverizer, pulverized and distribute the coal to boilers and furnaces is 30 K.W. hours per ton. The power at 1 3/4¢ per K.W. equals 52 1/2¢ and we have figured 20¢ a ton for repairs and upkeep which makes 72 1/2¢ per ton, and in the forging calculations we have figured this at 75¢ per ton. If the cost of power is different you can change your calculations accordingly.

The labor item we have not considered for it should not take any more labor to operate the coal plant and boilers than it now takes to operate the stokers.

For the pulverized coal installation we would advise the following equipment in connection with the present coal handling machinery. On the under side of the present coal bunker that is located in front of the boiler, place cast iron gates to deliver the coal to a 24" belt conveyor. Magnetic separator to be placed over belt conveyor to extract the magnetic material from the coal. 5 H.P. Spur Gear Reducer to drive belt conveyor.

Steel Hopper Belt Conveyor to Dryer.

One 5' - 0" dia. x 50' - 0" long Rotary Coal Dryer.

One 15 H.P. Silent Chain Driver to drive Dryer.

One 6" Dust Removal Screw Conveyor to convey the coal dust that may accumulate in stack end of dryer to screw conveyor leading to pulverizer.

One Automatic Recording Thermometer to record the temperature of the coal as it leaves the dryer.

One 12" Screw Conveyor Dryer to dryed coal bin.

One 3 H.P. Spur Gear Reducer to drive screw conveyor.

One 5 ton Dryed Coal Bin.

Two 5 ton per hour Bonnot Pulverizers.

Two 75 H.P. Silent Chain Drivers to drive the pulverizer

Two 60" Bonnot Exhausters with the necessary piping and collectors to convey the pulverized coal from the pulverizer to the pulverized coal storage bin.

One 50 Ton Capacity Pulverized Coal Storage Bin with the necessary feed screws.

Automatic Regulator, vent piping, collectors, blowers, distributing pipe and burners for suppling the boilers with pulverized coal.

The forge and heat treating departments will require in addition to the above, one additional 50 ton pulverized coal storage bin with the necessary feed screws, automatic regulators, vent piping, collectors, blowers, distributing piping and burners for conveying the pulverized coal to the furnaces.

T The cost of our equipment to serve the boilers would be $6,000.00 with $15,000.00 additional for the equipment for forging and heat treating furnaces.

The pulverized coal machinery will require a building 40' - 0" x 80' - 0" x 46' - 0" high to the eaves.

The total cost of a pulverized coal installation to serve the boilers and furnaces would be as follows:

Pulverized coal machinery $75,000.00 Electric Motors, Secondary Air Blowers and piping for same, changing of furnaces, vents for stacks for carrying off the gases, erection of machinery and building $50,000.00 making a total of $125,000.00 for the plant complete ready to operate.

As long as coal and oil remain at the present prices, the saving of $19155 per year on an investment of this kind is considered low. However, if the price of oil should advance and coal come down in price, the proposition to install pulverized coal equipment would become very attractive. We are enclosing three cuts of the Burhham Plan which will give you some idea of the machinery required for an installation of this kind.

The track hopper and elevator are already in place so that the 24" belt would receive the coal from the present bunker and deliver it to the chute leading to dryer.

The following report from the Combustion Economy Corporation seems to be a very preliminary report and really does not give a comprehensive solution of the problem. It appears, in comparison with the Quigley report, to be a very general estimate and on the face of it, shows very little work on the part of the Company. In substance the report is :-

COMBUSTION ECONOMY CORP.

| | | | |
|---|---|---|---|
| 4 - 400 H.P. Boilers. | - 5,760 | lbs. | per hour. |
| 2 - 550 H.P. " | - 3,960 | " | " " |
| 1 - 870 H.P. " | - 3,000 | " | " " |
| Total - - | 12,720 | " | |

We note that your total tonnage now is about 80 tons per day, indicating that the boilers are not fired at 100% Rating 24 hours per day. We would therefore suggest that you figure on a saving of 20% in fuel costs fired at the boiler. You would need approximately 20 tons of coal per day on the different furnaces, which would make a maximum of 100 tons per day for firing a pulverizing plant with a capacity of 7-tons per hour.

The approximate cost of the complete installation would be as follows:

| | |
|---|---|
| Pulverizing Equipment - - - - - - - - - | $63,000.00 |
| Building for Pulverizing Plant | 11,500.00 |
| Conveying System, complete, for handling the coal to the different furnaces and boilers. - -- - - - - - - - - - - | 5,875.00 |
| Firing Equipment for Boilers | 36,500.00 |
| " " " Furnaces | 32,450.00 |
| Approx. Total Cost of Complete Installation - - - | $149,325.00 |

The combustion Economy Corporation report seems to cover, in a highly thereotical way, a saving that might result from a change in the boiler room from stokers to pulverized coal. It will be noted that this company allows only 1.5 ¢ per K.W. hr. for power, while the Reo Co., pays 2.5¢ per K.W. hr. This would make the power item $37.95 instead of $22.77 as given in their report.

We are sorry to say that the Reo Power Plant does not have a daily log sheet, nor have they any data available as to the efficiency of the boilers. This is a great handicap in making out a problem of this sort. Therefor we consider that this company has given us so far as it is possible, as good a report on the saving to be obtained.

It will be noted that this company does not believe that it would be economical to change from oil to pulverized coal in the heat treat furnaces.

The report is as Follows:

COMBUSTION ENGINEERING CORP.

Assuming an efficiency of 65% and using a coal consumption of 80 tons per day as given, the present steam load would be approximately 40,000 B.H.P. hrs. per day.

Cost at Present

| | | | |
|---|---|---|---|
| Fuel ....80 tons | @ $7.10 a ton ........ | $568.00 | |
| Labor ...52 hrs. | 60¢ ............ | 31.20 | |
| | | | $599.20 |

Making a cost per B.H.P. hr. of .015

It may be that on looking over the plant you can decide that the efficiency as assumed is not correct, and in that event you can change the above figures to suit.

The cost with pulverized fuel based on the same load as above and assuming coal of 13,000 Btu would cost, pulverized to the plant, $7.10 per ton, and assuming an operating efficiency of 78% which is easily obtainable with pulverized fuel, we arrive at the following figures which are approximately correct:

Fuel .........66 tons @ $7.10 a ton .......468.60
Power for preparation of the coal and firing.
66 tons 23 Kw hr. per ton at.015 per Kw hr. 22.77

Labor covering the following men:

| | | | |
|---|---|---|---|
| 1 - fireman - 24 hrs | 60¢ | - | 14.40 |
| 1 - ashman - 12 hrs | 50¢ | - | 6.00 |
| 1 - pulv. attnt. 10 | 75¢ | - | 7.50 |
| 1 - dryer " 10 | 60¢ | - | 6.00 |
| 1 - conveyor attnt. - 10 | 50¢ | | 5.00 |
| | | | 38.90 |

| | | |
|---|---|---|
| Coal for dryer ... 1 ton @ $7.10 .....7.10 | | |
| Repairs & Lubricants ... 15¢ per ton handled ......................... | 9.90 | |
| | | 17.00 |

The cost of the preparation and firing equipment would be approximately $110,000.

Assuming interest @ 6%, taxes @ 2% and depreciation @ 8%, the total annual charge for the above would be $17,600 or on a 300 day basis $58.65 per day.

SUMMARY

| | |
|---|---|
| Fuel ........................... | 468.60 |
| Power ........................... | 22.77 |
| Labor ........................... | 38.90 |
| Coal for dryer, repairs & lubricants ....... | 17.00 |
| Interest, depreciation & taxes | 58.65 |
| Total ................................. | $605.92 |

$\frac{605.92}{40,000}$ equals .0151 per Boiler horsepower hour.

Based on 80,000 B.H.P. per day, the following charges would be approximately correct:

| | | |
|---|---|---|
| Fuel ...136 tons @ $7.10 per ton ....$ 965.60 | | |
| Power for preparation and firing - 23 KW per ton @ .015 per KW ............ 42.92 | | |
| Labor consisting of the following: | | |
| 1 fireman ..24 hrs @ 60¢ .......... | 14.40 | |
| 1 ash man ..12 hrs @ 50¢ .......... | 6.00 | |
| 1 pulv. attnd. 16 @ 75¢ .......... | 12.00 | |
| 1 dryer " ..16 @ 50¢ .......... | 8.00 | |
| | | 50.00 |
| Coal for dryer ..2.1 tons @ $7.10 | 14.91 | |
| Repairs and Lubricants 15¢ | 20.40 | |
| | | 35.31 |

## SUMMARY

| | |
|---|---|
| Fuel ........................... | $965.60 |
| Power ........................ | 46.92 |
| Labor ........................ | 50.00 |
| Coal for dryer, repairs and lubricants .............. | 35.31 |
| Daily charge for int. depreciation and taxes.......... | 58.65 |
| Total ............................. | $1156.48 |

$\frac{1156.48}{80,000}$ equals .0144 per Boiler Horse Power Hour.

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It must be noted, however, that in the stoker analysis no charges have been made for power, coal handling labor, maintenance or depreciation. You probably can secure these figures from the plant records and make due allowance for the same.

There are a number of advantages that might be mentioned in favor of the pulverized fuel, two of which are continuous operating at high ratings with high efficiencies, and saving over the stokers during banking periods.

With reference to the forging and heat treating furnace, we would not recommend the changing from oil to pulverized fuel on these furnaces for the following reasons:

First: A large number of the furnaces could not be arranged to burn pulverized fuel.

Second: All of the furnaces are small and coal could not be burned as efficiently as oil in any of them.

Third : Capital expenditure charges would more than offset any saving in fuel that could be made.

Fourth: For this class of work oil is much cleaner than coal.

The Fuller Engineering Co., gives a very general report on the problem, not going into detail at all. They, however, apparently consider that the proposition would be a feasible one and that a saving would be obtained by the use of pulverized coal. The estimated cost given, as will be noted, does not cover the cost of equipment for the furnaces. The main idea of the report is as follows:

FULLER ENGINEERING COMPANY.

The firebox on the 870 HP boiler is approximately correct for firing this boiler at normal rating, but from the information which we can gather from your blue prints, we feel sure that it will be necessary to have suitable combustion chambers of the dutch oven type installed in connection with the balance of the boilers even for normal rating. We also have assumed that there will be sufficient room for the installation of the auxiliary equipment including the pulverized coal bins, burners, feeders, etc., and further that a powdered coal plant building and equipment could be placed in fairly close proximity to the boiler room.

On a basis of a total daily consumption of 80 net tons of coal being consumed in 24 hours and assuming a combined boiler and furnace efficiency of 60% as the present average in your boiler room there would be a saving of approximately 23% when using pulverized coal or 62 net tons. 20 tons approximately would be required to do the same amount of work in the metallurgical furnaces operating with oil, which, added to the boiler requirements would make a total of 82 net tons of pulverized coal per day of 24 hours. On the boiler data sheet you should show that the B.T.U. value of the coal varies from 12,000 to 14,000 per lb. or an average of 13,000. With a fuel of this value and operating at 78% combined boiler and furnace efficiency, the evaporation would be 10.45# of water per lb. of coal fired or 3.3# of coal per boiler

HP hour. On the above basis of calculation there would be required a pulverizing plant including 2-42" Fuller Mills and this plant would have to operate 11 to 12 hours in order to take care of the total requirements.

We are familiar with the general construction of various types of metallurgical furnaces you refer to and we are of the opinion that the furnaces, other than the pot type, could be operated satisfactorily with pulverized coal if remodeled.

A pulverized coal plant of the size mentioned above would have a total maximum daily capacity in 23 hours of 160 net tons if operated continuously. The cost of the installation would be as follows:

| | |
|---|---|
| Coal plant Building | $16,035.00 |
| Coal Mill Machinery | 71,385.00 |
| Boiler Equipment for 7 boilers | 57,509.00 |
| Freight | 8,856.00 |
| Engineering | 14,493.00 |
| Total | $168,278.00 |

This does not include anything for the metallurgical furnaces.

The report of the American Industrial Engineering Co., is given below. This is more or less of a preliminary report. They base their failure to make a more complete and accurate report upon lack of data.

While we are quite well aware that the data furnished these companies was not as complete as could be desired, it is noticeable that there is a wide difference in the reports of the different companies.

We have no information on hand regarding the equipment and methods used by this company, as we have never received any literature from them. There are some interesting statements in their report which will be given below.

In analysing your data on the boiler plant we find that you consumed 24000 tons of coal for 24-hours, running 300 - days per year of normal rating, but we find in checking up this coal consumption, that the boilers must have been standing or operating only part of the time.

For the 2700-H.P. plant operating 24-hours the coal consumption will be approximately 226800 lbs. or 114-tons. The additional 870 H.P. boiler will consume in 24-hours 73080 lbs. or 36 tons, making a total for the boiler plant of 150-tons. The furnaces would consume 18-tons per 24-hours, basing our calculation on the fuel oil consumed, making a grand total of 168-tons per 24-hours.

We do not know the present efficiency of your boilers, but will say that we would be able to obtain an average, or at least 78% if fired with pulverized coal, providing of course, that the combustion chambers were changed to meet with the best operating conditions. Comparing the Reo Plant with a similar installation, however, we are quite positive that we shall be able to obtain at least 10% better results than you are now getting with your present stocker installation.

Pulverizing Plant:

We are figuring on a Pulverizing Plant consisting of the following machinery.

Building - 32' x 60' x 32' high
1 - Steel car hopper - 12' x 12'
1 - Reciprocating feeder below hopper
1 - Magnetic Separator - 18" x 36"
1 - Crusher - 24" x 24" single roll.
1- Raw Coal elevator - 25.5 ton per hour capacity. 43' center to center.
1 - 12" screw conveyor - 30' long.
1 - 100 ton capacity raw coal bin
2 - Reciprocating feeders for dryers.
2 - No. A - 4 Ruggles and Coles Dryers.
1 - Dry coal elevator, 12-ton capacity 37' center to center.
2 - 12 ton Dry Coal bins.
2 - 5 roller High Side Raymond Pulverizing mills.
1 - Shooting tank with scales.
1 - 250 cubic feet per minute air compressor with 50 - H.P. motor.

Motors for above:

1 - 24 H.P. motor for crusher
1 - 10 H.P. motor for raw coal elevator and magnetic separator .
2 - 20 H.P. motor for dryers.
1 - 5 H.P. motor for dry coal elevator
2 - 100 H.P. Motors for Pulverizors.

The burning equipment transport system for the Pulverized Coal and Circulating system for the small furnaces, we have not itemized in this estimate, neither have we attempted to go into detail figuring out the various foundations not knowing the condition of your ground, but believe that the amount put for same will meet the expenses. The total installation cost ready to run with necessary changes to furnaces will amount to approximately $155,000.00

Operating Costs:

The total operating cost of labor for coal delivered to furnaces, including cost for handling the coal and pulverizing would be 60¢ per ton.

The drying will require 25-lbs. of coal per ton, dry coal.

The total power required for crushing, elevating, grinding and blowing is safely put at 30 K.w. hours per ton of coal.

The total maintenance cost, including labor, spare parts, waste and lubricants will not exceed 7¢ per ton.

## Part V.

## Conclusions.

Considering the problem from the standpoint of present prices of coal and oil, $7.10 per ton for coal and 4.5¢ per gallon for oil, we believe that the installation of a pulverized coal system would result in a large enough saving in the boiler room to warrant its installation, but that the saving in the heat treat department would not be sufficient to make this change feasible.

In drawing our conclusions, we have taken figures, which we consider an average, from the reports of all the companies corresponded with. We are handicapped by the fact that the Reo Motor Car Company has no data of boiler room tests or daily log sheets; in short, they have not determined the efficiency of their boilers and stokers. Consequently, it has been necessary for us to assume efficiencies as the companies have done in their computations.

The figures on saving are as follows:

Fuel used, figuring from present boiler H.P. of 2700, using 80 tons of coal per 24 hours gives 2.5 # of coal per hour per boiler H.P. With the new boiler in use we have 3750 B.H.P. as a total @ 2.5 # per hour gives a total of 107 tons per day of 24 hours.

Assuming a combined efficiency of boiler and furnace at 60% with stoker installation, and a combined efficiency of 78%, which authorities claim is easily obtainable with pulverized coal, a saving of 18% is obtained. Therefore with the pulverized coal installation, 91 tons of coal per 24 hours will be necessary.

Now to obtain the cost pulverizing, drying, and delivering to the furnace, the following items will be assumed: K.W. hrs. required per ton of pulverized coal prepared and delivered to the furnace - 25.

Cost of power per ton - 63¢

Coal required for drying - 25# per ton.

Cost of dryer coal per ton of pulverized coal dried - 9¢

Labor hours required per ton - .5

Note: 112 tons is the amount of coal necessary daily for both the boilers and the heat treat furnaces. In as much as both are supplied from the same plant, the labor item must be spread over the total since 56 labor hours per day are required to prepare and deliver the coal. The average cost of labor is 60¢ per hour. Then the cost of labor per ton is .5 x 60 = 30¢. Total cost of preparation and delivery per ton equals $1.02 Therefore the total cost with pulverized coal per day would be $7.10 + $1.02 = $8.12. 8.12 x 91 = $738.92 per day.

A cost which can be considered in connection with the stoker installation is the labor required to operate the plant. At present this amounts to 48 labor hours per day at 60¢ per hour or $28.80. The superintendent of the power plant states that it would require no more labor with the 870 H.P. boiler in operation.

Therefore the labor cost per ton of coal burned with stoker installation would be 25¢, making a total cost for the coal handled $7.25 per ton. This amounts to 7.35 x 107 = $786.45 per day.

Subtracting the cost per day with pulverized coal from that with the stokers (786.45 - 738.92 = $47.53), the saving of $47.53 per day results. In a year of 300 working days this amounts to a saving of $14,259.00.

Next in considering the cost in connection with the heat treat department, we give the following data:-
It requires one ton of coal to equal 200 gallons of fuel oil, per day, it would require approximately 20 tons of coal to take the place of the 3900 gallons of oil now used. The cost of the oil equals 3900 x .045 = $175.50 . We have assumed that it required ten labor hours at 60¢ per hour to take care of the oil equipment. This makes a total of $181.50 per day for the cost of the oil.

Taking the figures obtained from the boiler room calculations, the cost of the pulverized coal per day would be 8.12 x 20 = $162.40. This amounts to a saving of $19.10 per day in the heat treat department, or for a year of 300 working days it amounts to a saving of $5730.00 .

The saving shown above for the heat treat dept. is not large enough to warrent the heavy expenditure of capital that would be necessary to make the change. The following are some of the reasons why we do not consider it to be feasible to change to a pulverized coal system in the heat treat department:

It would be necessary to discord or sell most of the present equipment at a heavy loss; the furnaces would have to be rebuilt to burn pulverized coal; and an exhaust system would be necessary in order to remove the products of combustion in the furnaces.

We also refer to the statement of the Combustion Engineering Corporation's report in regards to the feasibility of the change. However in case fuel oil again rises in price to that which was paid during the war, 13¢ per gallon at one time, it might be that the change would be warranted. The reason for the present slump in prices is the fact that many industrial concerns are shut down and the oil companies have a large supply on hand, probably in tank cars. When the time comes for normal output again, it is almost certain that fuel oil will rise in price again.

The Fuller Engineering Co. states that it would not be necessary to change the fire box construction of the 870 H.P. boiler for burning pulverised coal. However, they are of the opinion that the other boiler combustion chambers would have to be changed somewhat, even for normal rating.

It will be noted that nothing has been said thus far, of depreciation, repairs, insurance, interest and taxes. We have assumed that these items would balance each other in both installations. In making this assumption, we are using the paper "Pulverised Coal for Stationary Boilers" by Scheffler and Barnhurst, as an authority.

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Pocket has: 3 Blueprints

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